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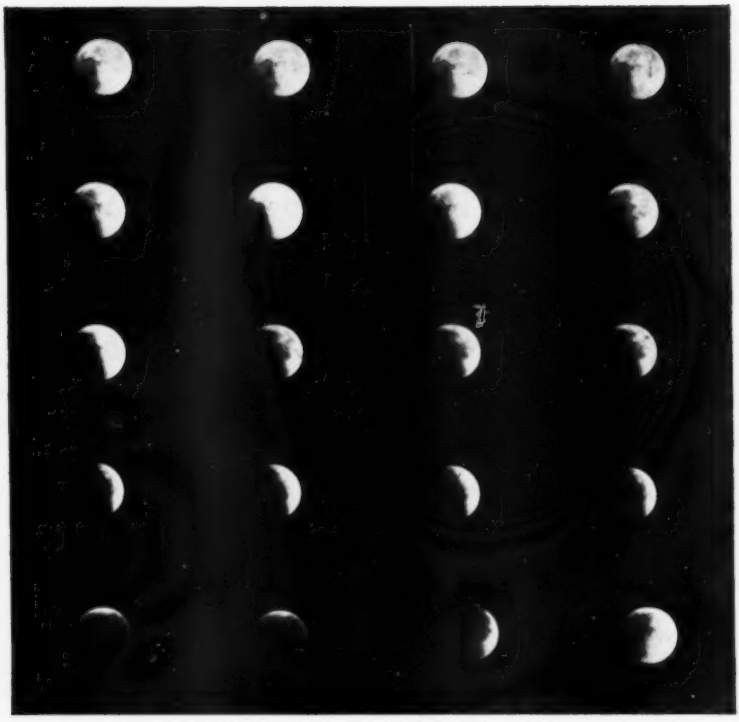
PLATE VI



PHOTOGRAPHS OF THE TOTAL ECLIPSE OF THE MOON, DECEMBER 18, 1945, MADE WITH A MOTION PICTURE CAMERA.

Selected photographs at various stages of the eclipse. The upper row shows the moon just entering the umbra and the three following rows present views deeper and deeper into eclipse. The lower row shows several photographs made during totality. The magnification over the original negative is 4 diameters.

THE JOURNAL

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A MOTION PICTURE RECORD IN COLOUR OF THE TOTAL ECLIPSE OF THE MOON DECEMBER 18, 1945.*

by

C. S. BEALS, R. M. PETRIE and A. MCKELLAR

(With Plate VI)

ABSTRACT

A motion picture on Kodachrome film was made of the total eclipse of the moon which occurred on December 18, 1945. A lens of angular aperture F 3.3 and 10 inches focal length was used in conjunction with a 16 mm. motion picture camera. The assembly was attached to the tube of the Victoria 73-inch telescope Exposures of 1/25 second were given during the partial phases and 20 to 30 seconds during totality. A satisfactory representation of all phases of the eclipse was obtained, the characteristic reddish colour of the totally eclipsed moon being particularly well shown. The results are discussed in some detail and suggestions are put forward for improvement of technique in future similar observations.

INSTRUMENTAL EQUIPMENT

PART of the equipment prepared at this Observatory for the observation of the total solar eclipse of July 9, 1945, consisted of a 16mm. motion picture camera, used in conjunction with a lens of 10 inches focal length and 3 inches clear aperture. It was proposed to make use of this camera, loaded with Kodachrome film, to photograph the entire course of the eclipse, employing a suitable filter and diaphragm to reduce the intensity of the sun's light during the partial phases and then to use the camera at full aperture to observe the corona during the period of totality. Unfortunately

*Contributions from the Dominion Astrophysical Observatory, No. 3.

the expedition on which this equipment was to be used (led by Dr. D. H. Menzel of Harvard College Observatory and located at Bredenbury, Saskatchewan) was clouded out and no observations were secured. However, it appeared that this camera, which had been initially prepared for the solar eclipse, would be equally well suited to observe an eclipse of the moon. Accordingly, it was de-

Fig. 1. The camera mounting showing the equatorial head, the driving mechanism and the guiding telescope. The brass cylinder carrying the lens and the block which supports the motion picture camera are visible. The camera itself has been removed. Adjusting the mechanism is S. C. Brown of the Toronto Centre of the Royal Astronomical Society of Canada. Photograph by F. Chappell.

cided to attempt to secure a motion picture record on colour film of the total lunar eclipse of December 18, 1945.

Figures 1 and 2 show two positions of the equipment as it was originally set up to observe the solar eclipse. The lens, which was considerably larger and heavier than the camera, was designed by Moffit for spectrographic work. It has an excellent colour correction and gives very beautiful definition over the field used. The diameter of the lunar or solar image is approximately 2½mm. It was mounted in a brass cell about 8 inches long. In order to make use of this lens with the motion picture camera, the cell was threaded into a

brass cylinder and the fit was made sufficiently snug so that micrometer focussing was possible by simply screwing the lens in and out without the necessity of any clamping device. A suitable scale for making settings was engraved on the circumference of the cell flange. At the other end of the brass cylinder there was fitted a brass nose-piece of ¾ inch outside diameter. This nose-piece fitted into a

Fig. 2. The mounting showing the motion picture camera, the Moffitt Lens (capped), the equatorial head and the driving mechanism. Operating the camera is R. S. Jervis-Read of the Victoria Centre. Photograph by S. C. Brown. These two pictures show the equipment as it was set up to observe the total solar eclipse of July 9, 1945. For the lunar eclipse the camera was mounted on the 73-inch telescope.

similar member in place of the usual short focus lens on the motion picture camera, and the two were held in contact by means of a spring clamp. Visual focussing was provided by substituting a small circular ground glass screen, suitably located, in place of the motion picture camera on the nose-piece. The motion picture camera itself was an Ensign Autokinecam which could be operated either by a spring and the usual push-button or by means of a hand crank. The use of the camera was obtained through the cooperation of Messrs. Hirst and Flintoff of Victoria. The support for

lens and camera consisted of a rigid oak block which is shown in the figures. Mounted on the block in a convenient position was a small finder telescope of 15 inches focal length for use in guiding.

As originally prepared for the solar eclipse expedition, the camera was mounted on a small equatorial mounting, driven by a synchronous motor and it was at first hoped to make use of the same mounting for observing the lunar eclipse. Unfortunately, however, the moon was very low in the sky during the period of the eclipse and there was not available at the observatory, any stand of sufficient rigidity from which a clear view of the eastern horizon could be obtained. It was accordingly decided to mount the camera on the tube of the 73-inch reflector and to make use of one of the finders of the large telescope for guiding. The camera was attached to the large telescope near the upper end so that the camera operator could stand on the observing platform designed for observations at the prime focus.

The Observations

Circumstances of the eclipse for Victoria were as follows:

Moon enters penumbra	15h	38m	Pacific	Standard	Time
Moon enters umbra	16	38	"	"	"
Total eclipse begins	17	40	"	"	"
Total eclipse ends	19	00	"	"	"
Moon leaves umbra	20	03	"	"	"
Moon leaves penumbra	21	02	"	"	"

The time of moonrise was 16h 13m and of sunset was 16h 19m P.S.T. At 16h 38m when the moon entered the umbra, its hour angle was 7h 27m east. However, it was favourably situated as regards declination, being at +23°.

The photographic programme was restricted by the large initial hour angle of the moon. The whole eclipse from beginning to end could not be recorded. Another limiting factor was that a length of only about 85 feet of Kodachrome film was available. This allowed a total of about 3500 frames to be exposed.

The camera was operated using the hand crank. One eighth of a turn of the handle exposed a frame. Markers of white adhesive tape were attached to the side of the camera to show the positions of the handle at which the shutter was open and at which it was closed.

A trial exposure had been made in the summer of 1945 using

film of the same speed as Kodachrome. The trial had shown that an exposure of about one twenty-fifth of a second was suitable for the uneclipsed full moon. Normal speed for the camera when operated with spring and push-button was 16 frames per second, or an exposure time of about one-thirtieth of a second. A short session of practice enabled one to approximate this speed using the hand crank.

Very little information seemed available on the relative brightness of the uneclipsed to the totally eclipsed moon, a ratio which may vary somewhat from eclipse to eclipse. However, a few estimates were found[1] which indicated the ratio to be of the order of 1000. Hence an exposure time of about 30 seconds seemed suitable for the eclipsed moon.

When the sky was dark enough, the motion picture camera was collimated with the guiding telescope (a 4-inch finder of focal length 60 inches attached to the 73-inch telescope) by setting on *Aldebaran*. Immediately thereafter photography of the moon, which was already almost totally eclipsed, was started.

One of the writers (C.S.B.) operated the motion picture camera from the observing platform near the upper end of the tube, the second (R.M.P.) guided using the 4-inch refractor mentioned above and the third, (A.McK.) kept track of the time, announced the beginning and end of the exposures and recorded necessary data.

During the early part of the observations, thin clouds interfered to some extent. However, from a few minutes before the end of totality onward, the sky was clear and conditions were very good.

Since this was the first attempt to take motion pictures of celestial phenomena at this observatory, it was considered worthwhile during totality to make a few exposures of an exploratory nature longer and shorter than 20 to 30 seconds. These should give useful guidance for any similar project in the future. Data concerning the exposures are listed below.

17h 37.5m to 17h 42.5m P.S.T. (partially eclipsed moon)—Four frames of about 1/30 second exposure at the beginning of each 8-second interval.

17h 43m to 17h 57m P.S.T. (totally eclipsed moon)—Consecutive frames, exposure 20 seconds each.

17h 57m to 18h 20m P.S.T. (totally eclipsed moon)—Consecutive frames, exposure 30 seconds each.

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[1]See, for example, Dyson and Woolley, *Eclipses of the Sun and Moon*, Clarendon Press, Oxford (1937) pp. 31-33.

18h 20m to 18h 40m P.S.T. (totally eclipsed moon)—Clouds drifted over moon.

18h 40m to 18h 43m P.S.T. (totally eclipsed moon)—Consecutive frames, exposure 30 seconds each.

18h 43m to 18h 49.5m P.S.T. (totally eclipsed moon)—Consecutive frames, exposure 20 seconds each.

18h 49.5m to 18h 55.5m P.S.T. (totally eclipsed moon)—Three frames, exposure 2 minutes each.

18h 55.5m to 18h 58m P.S.T. (totally eclipsed moon)—Twelve consecutive frames, first three of 2 seconds exposure, second three of 6 seconds exposure, third three of 12 seconds exposure, and fourth three of 20 seconds exposure.

18h 58m to 19h 00m P.S.T. (totally eclipsed moon)—Two frames, exposure 1 minute each. (End of totality occurred on schedule at 19h 00m).

19h 01m to 20h 08m P.S.T. (partially eclipsed moon)—Four frames of about 1/30 second exposure at the beginning of each 8-second interval.

20h 10m—— P.S.T. (moon uneclipsed except for penumbra)—Made about 125 turns (1000 frames) of full moon, about 1/30 second exposure each.

Discussion of Results

Upon development and projection the film was found to be successful, the changing aspects of the moon during the various phases of the eclipse being clearly depicted. It has been thought worthwhile to discuss one or two points of technique as our experience may be helpful to anyone contemplating similar work in the future.

The fundamental problem in celestial kinematography is that of accurate following and registration*. The tolerance here is less than allowed in ordinary motion picture work where, generally speaking, moving and shifting scenes are depicted. Astronomical subjects on the other hand are stationary, or move but slowly, and any departure from good registration becomes, upon the screen, a distressing "jumpiness" which detracts from the beauty and majesty of the phenomenon. It is apparent, then, that a rigid, vibrationless, mounting is required and also one that can be trained very precisely upon the subject being photographed. In our work the massive 73-inch reflector served admirably as a steady support for the camera while precise guiding was made possible with the guiding

*The problems peculiar to celestial kinematography have been studied in detail at the McMath-Hulbert Observatory. Dr. R. R. McMath and his colleagues have pioneered this field and have devised techniques resulting in very successful motion picture records of many celestial phenomena. The interested reader will find valuable discussions and advice in their papers in the *Publications of the Observatories, University of Michigan*, vol. 4, no. 4, 1931; vol. 5, no. 8, 1933; vol. 5, no. 10, 1934.

telescope already mentioned. With this telescope, and a one-inch eyepiece, a relative movement of the moon of a few thousandths of its apparent diameter could be detected. This arrangement was not without its disadvantages however. As the moon entered the umbra and the illumination decreased it became increasingly difficult to see the guide point, a small isolated peak. At times during totality it could not be distinguished and the registration suffered in consequence. This feature of a lunar eclipse cannot be avoided entirely, but a better plan would have been to select a larger bolder guide point such as a well-defined crater and to accept less accuracy during partial eclipse in favour of overall performance.

A feature, peculiar to lunar photography, may be noted here. Due to its rapid motion across the heavens the conventional sidereal rate plus the usual slow motion in right ascension is not adequate to follow the moon. Anyone planning lunar motion picture records should make sure that the driving rate is sufficiently flexible to allow for the above effect. In our case matters were made more extreme due to the moon being near the eastern horizon and it was necessary at times to resort to the "accelerated" slow motion to maintain registration;—a practice not to be recommended.

A frequent source of difficulty in this work is the camera drive, and our technique in using manual control left a good deal to be desired. The intermittent turning of the camera crank introduced vibration easily seen in the guide telescope and detectable, although not serious, upon the film. It is essential for best results that the motion-picture camera be provided with a smooth mechanical drive, motor operated if possible.

A major problem in work of this nature is the estimation of the correct exposure which often must vary from beginning to end of the film. As mentioned above, we knew the exposure for the uneclipsed full moon but data upon the relative brightness of the eclipsed moon were scanty and conflicting. However, our exposures of 1/25 second for the full uneclipsed disk and 30 seconds during totality gave clear, well-exposed, images. It was estimated, however, that totality on December 18 was brighter than the average and that exposure ratios of 1000-fold would be better values to adopt in planning future observations.

It was interesting to note that observations of the light of the totally eclipsed moon at this eclipse were reported recently in this

JOURNAL by F. L. Tabrah and R. M. Tabrah[2]. These authors found a drop in light to some 2 per cent. (their lowest step) of that of the uneclipsed moon. It is felt, however, that due to the changing colour of the eclipsed moon and the great accommodation of the human eye, it is not possible to make accurate comparisons of this kind. Certainly our film indicates that the eclipsed moon was much less than 1/50th as bright as when out of eclipse. There is need for such observations and it is hoped that they will be continued at future eclipses, with perhaps, more objective methods for measuring the loss of light. It is tempting to try to estimate, from our film, the decrease in light during totality but this has not been done because the use of colour film, without a filter, for the estimates would give results which would probably not be significant and might well be misleading. We have contented ourselves. therefore, with giving the above exposure ratio for the full and uneclipsed moon which will result in photographs of the proper relative exposure for the two aspects.

An examination of our film suggests that if exposures had been graduated from 1/25th sec. for the uneclipsed moon to, say, 30 sec. during totality, the latitude of the film would have permitted both eclipsed and uneclipsed parts of the disc to be photographed simultaneously. This would have resulted in a more striking picture and the point should be considered carefully by anyone proposing to make a film of a future eclipse.

Despite the above criticisms and shortcomings it is considered that our experiment was successful, the film providing a good visual description of an interesting and beautiful celestial phenomenon. It is especially gratifying to note that the colour of the eclipsed moon, perhaps the most attractive feature of the whole spectacle, was faithfully reproduced. The accompanying plate, showing a few frames of various aspects during the eclipse, gives an idea of the performance of the equipment. It is hoped to have the original colour film copied in the near future so that it may be made available to astronomical groups and other interested bodies.

It is a pleasure to acknowledge the help of Mr. S. S. Girling who designed and constructed the lens and camera mounting and the driving mechanism illustrated in figures 1 and 2.

Dominion Astrophysical Observatory
Victoria, B.C., February 25, 1946.

[2]J.R.A.S.C., vol. 60, p. 23, 1946.

HER MAJESTY'S MAGNETICAL AND METEOROLOGICAL OBSERVATORY

By A. D. Thiessen

(*Continued from page 408, Volume XXXIX*)

In this next letter the strained relations between Lefroy and Sabine first become apparent.

Toronto, July 31, 1850.

My dear Colonel,

My letter of July 25 having been late for the post, I rewrite it according to your wish, on thin paper.

I wish to state that while I have felt much disappointment, and an equal sense of grievance, as to the difficulties raised, and the alterations introduced, most unexpectedly to me, into our plans with reference to the Athabaska Observations, plans which I had every reason for the last three years to believe to be perfectly settled and well understood, yet I am desirous of accomodating myself to what now appears to be the only course open to me, and provided the observations are published fairly and fully, shall endeavour to give as little further trouble as I can in respect to the mode of publication. In fact my last anxiety and remonstrance has not had reference . . . much to the change in the medium of publication as to the question which your letter of May 29 seemed to throw open, as to whether they could be or ought to be published at all. I gather from subsequent letters a satisfactory assurance that this apprehension is groundless. It is true that Younghusband in his last letter seems to have got the impression that my wintering in the North was unauthorized, and that observations taken under such circumstances can have no claim to official publication, but this impression is wholly inconsistent with the facts, and with the whole tenor of your correspondence and Riddell's during and after my residence there, as well as with your letters of March 3 and May 17, 1847, that I am satisfied no such ground can be taken, or is intended to be taken. If when you began to "forsee the difficulties" which it is evident were not suspected at the date of the letters to which I have just referred, some warning had been given me, I could have had no cause of complaint, and should not have let one idea and one expectation get possession of my mind. I submit to you that the absence of the least intimation of any possible or expected difficulty, up to the moment when I am abruptly given to understand that the publication of the observations in any way will be a matter of grace and favor, and highly uncertain, (for I can have assurance that the Royal Society will print a paper on such a subject if I prepare it), is an occasion of reasonable complaint, and that no one circumstanced as I am, under the disadvantage of absence from the quarter in which the matter must be decided, can fail to feel as I have done about it. I shall feel much obliged by your reference on the first opportunity to those two letters (March 3, May 17, 1847) that you may see whether I have proceeded without good grounds in the arrangements I have made, and in the expectation I have entertained.

I am desirous however, as I have already stated to forget this painful discussion, and to acquiesce in whatever arrangements may under the actual circumstances be best and most feasible.

Lloyd's letter, a copy of which I have sent, seems to leave us at liberty to proceed with the Athabasca disturbances without alteration of anything, save only that I would be careful to head each column of $\Delta\theta$ and $\Delta\phi/\phi$ with the word "approximate" and to give an account in the introduction of the method employed. His remark respecting the inclinometer coefficient applies equally to all our observations here, prior to August 1847. I have before pointed out that the criterion to which he seems disposed to refer the question, namely the harmony of the results, is quite in favor of our coefficients. I regard the circumstance that with very small differences from small scale readings, we have both + and − values of $\Delta\phi/\phi$ in the same disturbance, is conclusive that neither $\Delta x/x$ nor $\tan\theta\Delta\theta$ is affected by any large coefficient of error, because if it were, that coefficient whether more or less than unity, would constantly affect the erroneous member of the equation $(\Delta\phi/\phi = \Delta x/x + \tan\theta\Delta\theta)$ with the same type, and since positive changes of x almost invariably attend negative changes of θ, and vice versa. If either number were unduly exaggerated or unduly reduced by such unknown coefficient, the results would all tend to have the corresponding sign. There would not be changes from + to − and from − to +.

The whole of the disturbances as well as the disturbed term days of October 1843, Jan., April and May 1844 will be contained in 43 pages of 63 lines each in double column. The space occupied by footnotes relating to the aurora will perhaps cost another page or two. Your list as sent to me, did not extend beyond February, but the disturbances from October 1843 to February 1844, falling on days included in it, will only require 11 pages of double column, this includes two term days. From the great length to which the Disturbance of April 16 and 17 runs being fully equal to a Term day, I imagine as much more will be taken up by April and May, the Term days being included.

The course I followed with respect to the normal values was fully explained in a part of the M I which you do not appear to have read, when you wrote. It is different from yours to the extent only of applying one and the same mean diurnal value or curve to all the observations, instead of a different one for every month. The final mean derived from the whole period of observation was adopted as the best normal mean value, and to correct for instrumental change, or real change of each element between the date of the several disturbances and the date to which this mean curve belongs, (namely the middle period of observation.) The first differences $\phi - \overline{\phi}$ thus taken out received a subsequent correction constant for the same disturbance, but different for each of them, for the difference between the true mean for the epoch, and the mean of the quantities actually employed. This true mean for the Epoch was found by a group of n days having the disturbed day in every case for their centre. The disturbances at Fort Simpson are referred directly to means thus arrived, and no attempt is made to eliminate the regular changes. In either case, either the means for all the days of observation, or the means for the several months, whichever you prefer, can precede the disturbed observations. As single months do not give very regular

means in such high latitudes I should prefer the former. The circumstance that so many coincident dates of disturbances are found at Prague and at Van Dieman's Land does indeed appear inconsistent with the idea of local origin unless it can be shewn that these disturbances are also local. I presume that independent local disturbances may coexist, if local disturbances exist at all. You will perceive what Lloyd says. Certain it is that Toronto, Philadelphia, Sitka, Greenwich, and Makerstoun furnish very coincident dates. The last station gives the most, but there are very few *observations* made at any of them, as I presume is the case at Prague also. Referring again to your letter of July 4th, I observe that you enquire the number of pages these observations may occupy, on "the supposition that I am myself content that they should be printed in the place and in the form which you have pointed out." There can scarcely be any uncertainty at present on this point, but to settle the question I beg to say that I am now quite contented that they should so appear. The idea of an extended appendix to the next Toronto volume, as proposed by Riddell in 1845 and by yourself in 1847, having been, I presume, necessarily abandoned, I can have no further reluctance to that arrangement. I still suppose that the abstracts will appear there, with a very short résumé of results. As for the short section of meteorology I suppose it must be offered to the British Association, and the section on the Aurora, which is what Prof. Henry refers to, be reserved for some future general report on all that has been done, and is doing, to elucidate that subject. With reference to the suggestion of your private note I shall make it a point, and feel it a pleasure to attend to it. There is a section not quite completed, and therefore not forwarded on *shocks*, and in which your method is fully followed out. I have found the daily mean irregular fluctuation for each day at all the stations, and compared the shocks. Owing however to the absence of disturbance during this whole period at Toronto, the value of the *monthly* mean irregular fluctuation to which shocks are referred is in some cases so low, that I found that by retaining your limitation (double that value) all the readings on entire days, came under the definition and was obliged to adopt *three times*. I think this, which appears to me an inherent disadvantage of that method, deserves your consideration. I believe that I quite understand the difference which you point out between the causes producing perturbations properly so called, and those which produce inequalities in the regular diurnal action; I also admit, that by stopping where Lloyd does in the process of calculation these two causes or classes of effects are not separated. On the other hand, by this process the law of the joint effect is brought out very elegantly, and with much less labour. Moreover your method cannot be fully applied at stations where disturbance is the rule, and regularity the exception without a much longer continuance of observation than is necessary where the reverse is the case, much longer period than for example my observations cover.

I have only to add on this subject that I have commenced a paper on the *results* for the Royal Society.

Believe me, Yours truly,

J. H. Lefroy.

Lefroy was anxiously looking around for a better source of fuel for his photographic lamps than oil. Too much time had to be spent cleaning lamp shades.

Toronto, August 1, 1850.

Dear Colonel,

I am much obliged to you for sending my report on the Aurora to Sir H. Ross and for transmitting his letter. My reason for not doing so myself, was simply and solely a needless reluctance to appear to put myself forward, or to invite notice of [so] simple a matter. I had at first several of the Woolwich Staff on my list, but finally sent it only to the N.C. Officers library, to Col. Campbell, Col. Burn, The Institution, Wilmot, Smythe, and Dixon. I did not properly consider that all the safety was on the side of sending it, and the risk of being misunderstood on the other. I sent it home to all the commanding officers, R.A. and R.E. and to many of the officers. It has been reprinted in the Regent's report of this year, being the fourth reprint to my knowledge, a curious proof of the general interest taken in the subject, as well as the want of definite information on it. In this connection I beg your notice of Prof. Henry's proposal. (Letter 1)

With reference to your letter of June 28, I very readily withdraw the conditional clause of my letter of June 6, to which you object, and which I should not have introduced at all had I expected the prolongation of my service to be for two years only. I believe that period will be enough for every purpose, and feel it a satisfaction to have something definite to prepare for. I trust we shall be in a condition by that time to wind up all our affairs with abundant proof that the liberal support of Government, so much beyond the period formerly contemplated, has been well bestowed. Your letters of July 4 and 10 have removed the impression I was under that during your recess from the duties of the officer at Woolwich you did not desire or intend to occupy your mind with its affairs. The last week in June having been named as the latest date at which my letter relating to the direction of the the Observatory ought to reach you, I have not addressed you since I took for granted that Mr. Ronalds would communicate my letter of June 4 or its information to you, and having very little time, and another matter to write about, I postponed the subject of his letter for another occasion, always intending to give a detailed account of everything as soon as matters were a little settled.

The various slight injuries to the apparatus were soon repaired and at small expense. I was obliged to have a new stirrup for the Bifilar adjustments, as Younghusband's had not sufficient command of circular motion. I have also after trying a temporary detached telescope, attached one of those belonging to the Athabaska Transportables, permanently to the instrument, so as to make it a part of the apparatus, and as firm as the rest. These arrangements were not completed before the 27 June. I then completed an adjustment in the usual way. The instrument being adjusted, I proceeded to determine a coefficient of scale values *by deflection* N. and S. Then removing the scale or table on the S side, the slider case, clock, etc., were fixed and adjusted, a plate being then prepared, the experiments of deflection on the N. side were then repeated, scale readings

being taken simultaneously with the admission of light, in each position of the magnet, to the surface of the plate, by this means a series of dots having a known scale interval, was marked on the plate, which fortunately proved a good one. This was done twice (on two plates). The result was that 1 inch on the plate = 61.16 scale divisions = .01323x whence one division on the ordinate scale of 50 to the inch, which is the one I use = .0026 inch. It can be read with considerable nicety to tenths = .00026, being equivalent to 7/10ths of our division of the scale of our other Bifilar, and to between two and three divisions of the original instrument. Considering however that an equal nicety is required at the same monent in the coincidence of the zero of the scale with the base line, I do not think that the accuracy of the ordinates can be regarded as within this limit. These experiments will have to be repeated from time to time. I am at present waiting for the arrival of Mr. Brooke's bifilar to repeat it on both instruments at the same time. The *Gentro* arrived at Quebec on the 21 July, but I have not heard of the cases yet. I intended to commence the daily register on the 1 July, and have applied a plate every day since, unless prevented by some cause or other, but of the whole number not one has been perfectly successful, and fully half came out blanks. There have been various causes for this failure, imperfect polishing, damp, but above all, as I have recently convinced myself, *over-coating*, want of allowance for the great heat of the weather, and excess of vapour in the batteries. A very skilful professional operator to whom I often refer, and who cleaned and coated a plate one day for me, met with very little better success. The impression was partial, as it is in most of mine. The consequence generally is a loss of definite points for determining the time. I hope to get the better of all this by degrees. The difficulties with large plates increase in a much higher ratio than their dimensions, and until overcoming them I have thought it best to confine myself to one instrument. I fear that your estimate that each plate will stand 35 or 40 cleanings, is greatly beyond the mark, but they can be resilvered in New York, if not here. I sometimes get things electroplated in Toronto, but it is not very well done. Plates are manufactured largely in N.Y.

I have tried two or three plates, and several slips of paper in the V.F. instrument. The instrument can be used very favourably with paper, the effect of daylight upon it being very strong, but I am concerned to see the apparent want of sensibility of the instrument. The lines are almost straight. This *may* however be due to accidental obstructions. I have already had to dispossess some spiders. I therefore reserve an opinion until I have more thoroughly studied the instrument. A defect about which there is less room for doubt is the total absence so far as I can discover of any means of determining the values of the changes recorded. I have written to Mr. Ronalds about this, and for a temporary check resumed regular observations of the other V.F.

I believe that the arrangements of the room *are complete* and satisfactory. It is rather too small, and I now regret not having when the floor was up, built a chimney, as it will be absolutely necessary to warm it, and to dry the air artificially. I have for these purposes ordered a copper stove, the cost of which will be about £5. We have already two copper stoves, but they are equally wanted elsewhere.

There is one point of great importance to be determined: the nature of the artificial light to be used. I fear we shall after all be absolutely precluded by the

expense from the regular employment of olive oil, unless you are prepared to apply for an increase to our Contingent money. The price of the best oil here is 12/6 Cy a gallon. The daily consumption for five lamps, three of them burning 24 h., and two of them averaging 14 h. a day, cannot be much under half a gallon, including wastage. Mr. Ronalds being very particular in rejecting all coarser remains, this will amount to more than £100 a year.

We are about 1000 yards distant from the nearest Gas main, and I find by enquiry that the Gas Company will only supply us upon the condition that we pay for the taking up and putting down the temporary pipes, also the interest upon their value, the Gas then costing 16/4 Cy per 1000 feet, cash payment. This would be little or no economy though otherwise preferable in every way.

There remain two resources—first, to manufacture Gas for ourselves; secondly, to use Camphine, making it ourselves (the process being a very simple sort of distillation) or procuring it from New York, as may be most advantageous. I have written to Mr. Renwick about a patent apparatus for the domestic manufacture of Gas, which is described to me as economical and simple. Meanwhile I am using oil but have not in a single instance succeeded in marking the plates by it. The paper is very feebly marked. I believe that the great economy and superior photogenic properties of Camphine will oblige us after all to make universal use of it. And am in hopes of incurring a *comparatively* small expense in procuring it direct from the distillery, and in keeping it always in *ice*, we may avoid most of the past inconveniences. It will not be *half* the expense of oil.

The very beautiful discovery of Mr. Ronalds that traces may be printed from the etching on gelatine paper, removes a great difficulty. I had tried several modes of tabulating ordinates without satisfying myself. I fear it will, like everything else connected with this method, be expensive.

I have had an electroplated copper cylinder, gilded over the cylinder, made to replace the glass cylinder of the damaged instrument, and purposely reduced by circumference to give the same time scale as Ronalds' instruments. Our old time piece turns it without any difficulty, being capable of much better support than a glass cylinder. Mr Ronalds is quite in favour of reducing the time scale and making each plate serve 24 h. as I proposed to him. By his advice I have had an experimental wheel turned in wood, to try it. I hope next week to have to report the completion of our photographic arrangements.

Believe me, Yours very truly,

J. H. LEFROY

I transmit copies of some letters.

The paging of your paper must have been altered after the proof sent to me, which goes from p. 283 to p. 301.

(*To be continued*)

LES ANNALES D'ASTROPHYSIQUE AND FRENCH ASTRONOMY DURING THE WAR

By C. S. Beals

AN announcement of the greatest interest to astronomers in Canada and elsewhere throughout the world has recently been made by Dr. D. Barbier, Editor in Chief of *Les Annales d'Astrophysique*—the major French astronomical publication. The French astronomers grouped in the Astrophysical Service which is associated with the National Centre for Scientific Research of France, have decided to transform *Les Annales d'Astrophysique* into an international reveiw publishing astronomical articles in French, English and German. This decision was reached at a time when the *Zeitschrift für Astrophysik*, which formerly fulfilled a similar function, had ceased publication, creating a definite need for a new publication of this kind. The purpose of the new review is to provide an international medium of publication, open to the astronomers of all countries but which would be of special service to those which do not have major astronomical journals of their own.

Les Annales d'Astrophysique is published under the authority of the Astrophysical Service of the National Centre for Scientific Research of France. The Executive Committee of the Service is responsible for the work of the Astrophysical Institute of Paris, and the Observatory of Haute Provence, as well as of the publication of *Les Annales d'Astrophysique*. The personnel of the Committee, which is nominated by Monsieur F. Joliot-Curie, director of the National Centre for Scientific Research, is as follows:

President, M. Danjon, Director of the Observatory of Paris; Vice President, M. Chalonge, Astronomer of the Observatory of Paris and of the Institute of Astrophysics; Secretary, M. Mineur, Astronomer of the Observatory of Paris and Director of the Institute of Astrophysics.

Members: M. Barbier, Astronomer of the Observatory of Paris and of the Institute of Astrophysics and Editor in Chief of *Les Annales d'Astrophysique*: M. Coulomb, Director of the Institute of Geophysics of Paris; M. Dufay, Director of the Observatory of

Haute Provence; M. Fehrenbach, Assistant Director of the Observatory of Haute Provence; MM. Lyot, Couder, L'Allemand, Astronomers of the Observatory of Paris.

In addition to the French committee which assumes the responsibility of finance and management and of making all final decisions concerning *Les Annales d'Astrophysique,* a group of foreign correspondents has been nominated whose function is to act in an advisory capacity and who are to be consulted on major questions of policy. It is expected also that the foreign correspondents will help in the refereeing of papers, preparing book reviews and maintaining the liaison necessary for full scientific co-operation between different countries. It is also expected that, in general, papers submitted to *Les Annales* from foreign countries, will first receive the approval of one of the correspondents from the country concerned. One of the features of the new publication is to be a column devoted to news of astronomers and observatories throughout the world and reliance will be placed on the foreign correspondents to furnish material for this column. The personnel of the group of foreign correspondents is at present as follows:

Abetti (Florence); Beals (Victoria); Fessenkov (Moscow); Gaviola (Cordoba); Lindblad (Stockholm); Mayall (Lick); Merrill (Mt. Wilson); Oort (Leyden); H. H. Plaskett (Oxford); Redman (Pretoria); Russell (Princeton); Shapley (Harvard); B. Stromgren (Copenhagen); Struve (Yerkes); Swings (Liege).

Of interest in connection with the above announcement is an account of French astronomy during the war which has been given by M. Chalonge.[1] In it he points out that while most of the French astronomers survived the war in good health, this is by no means the case for all. Two—Holweck and Solomon—were executed; Mineur was imprisoned for a time, while a number of others, presumably younger staff members, were confined to concentration camps or deported to Germany. A number of observatory personnel who were dismissed as a result of racial discrimination have been restored to their posts since the liberation. Numbers of French astronomers worked in the seclusion of the observatories to give asylum to fugitives, to provide places of meeting for resistance organizations as well as hiding places for arms and printing presses.

[1] *Observatory vol. 66, p. 23, 194.*

In spite of the disturbed conditions of the country a creditable amount of scientific work was carried out during the war. Two numbers per year of *Les Annales d'Astrophysique* were issued dealing with a wide variety of astronomical subjects. Work proceeded on the buildings of the Observatory of Haute Provence, while plans were formulated for improvement of the equipment of the Observatory of the Pic du Midi. Work on the interior of the new Astrophysical Institute of Paris (an institution designed to serve as the centre for French Astrophysical Research) was carried on secretly in defiance of the occupation authorities who had ordered the project closed. Part of the building was brought to completion and is now occupied.

It is pleasant to learn of this record of creative work carried on during a period devoted so largely to destruction and the writer would like to offer congratulations and best wishes for the future to his French colleagues.

Dominion Astrophysical Observatory,
Victoria, B.C.

Additional accounts of the work on the sun and planets during the war may be found in the *Astrophysical Journal, vol. 101*, p. 254-260, March, 1945.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

Lunar Eclipses

THE lunar eclipse of October 4, 1884, is cited in several text-books in current use as being the last lunar eclipse during which the moon became totally invisible. Actually, from a perusal of eye-witness accounts at that time, it appears that the moon did not become invisible during this eclipse.

It is worthwhile then to consider accounts of the eclipses which have occurred since the invention of the telescope, during which the eclipsed moon disappeared completely, so that no trace of it could be seen in the sky, either with the naked-eye or with a telescope. There appear to be three such cases; the eclipses of April 25, 1642, of May 18, 1761, and of June 10, 1816. To these may be added the abnormal obscurity of the moon in the eclipses of December 1601, of June 1620 and October 4, 1884.

The eye-witness descriptions of these remarkable events, along with other comments on lunar eclipses follow. The descriptions of the 1884 eclipse will be summarized in our next issue.

From Chambers, G. F., *A Handbook of Descriptive and Practical Astronomy,* 4th ed. 1889, p. 327.

Even when most deeply immersed in the earth's shadow, our satellite does not, except on rare occasions, wholly disappear, but may be generally detected with a telescope (and frequently with the naked eye), exhibiting a dull red or coppery colour. This was exemplified in a very remarkable manner in the case of the eclipse of March 19, 1848, on which occasion the moon was seen so clearly that many persons doubted the reality of the eclipse.

Mr. Forster, who observed the eclipse at Bruges, writes as follows:—

"I wish to call your attention to the fact which I have clearly ascertained, that during the whole of the late eclipse of March 19, the shaded surface presented a luminosity quite unusual, probably about three times the intensity of the mean illumination of the eclipsed lunar disc. The light was of a deep red colour. During the totality of the eclipse, the light and dark places on the face of the moon could be almost as well made out as on an ordinary dull moonlight night, and the deep red colour where the sky was clearer was very remarkable from the

contrasted whiteness of the stars. My observations were made with different telescopes; but all presented the same appearance, and the remarkable luminosity struck every one. The British Consul at Ghent, *who did not know there was an eclipse,* wrote to me for an explanation of the blood-red colour of the moon at 9 o'clock." (*M.N.*, vol. 8, p. 132, Mar. 1848).

As a complement to this observation, I may quote one by Wargentin of the total eclipse of May 18, 1761. He says that 11*m* after the commencement of the phase—

"The moon's body had disappeared so completely, that not the slightest trace of any portion of the lunar disc could be discerned either with the naked eye or with the telescope, although the sky was clear, and the stars in the vicinity of the moon were distinctly visible in the telescope."

Phil. Trans., vol. li, p. 210, 1761. The original runs thus: "Tota luna ita prorsus disparuerat, ut nullum ejus vestigium, vel nudis, vel armatis oculis, sensibile restaret, coelo licet sereno et stellis vicinis in tubo conspicuis." Other eclipses, where the same thing occurred, took place on June 15, 1620 (Kepler, *Epist. Ast.*, p. 825); April 25, 1642 (Hevelius, *Selenog.*, p. 117); and June 10, 1816 (Beer and Mädler).

von Humboldt, A., *A Physical Description of the Heavens.* Sabine's translation. 1867, p. 355.

In total lunar eclipses it happens in some exceedingly rare cases that the moon disappears wholly; it did so, according to Kepler's earliest observations (*Paralip. vel Astronomiae pars Optica*, 1604, p. 297), on the 9th of December, 1601; and in more recent times, on the 10th of June, 1816, in London, when it could not be discerned even with telescopes. A peculiar, not sufficiently explained, state of the several strata of the atmosphere in regard to transparency must be the cause of this equally rare and curious phenomenon. Hevelius remarks expressly, that, in a total eclipse on the 25th of April, 1642, the sky was covered with sparkling stars, the air being perfectly clear, and yet, with the very various magnifying powers which he employed, the moon's disc continued without a trace of visibility. In other also very rare cases, only some portions of the moon are faintly visible. In ordinary cases the disc appears, during a total eclipse, of a reddish hue, the colour being, indeed, of the most various degrees of intensity, passing even, when the moon is far removed from the earth, into a fiery glowing red. Whilst, more than half a century ago (29th of March, 1801), I was lying at anchor off the Island of Baru, not far from Cartagena de Indias, and observing a total lunar eclipse, I was exceedingly struck by seeing how much brighter the reddened disc of the moon appears in the sky of the tropics than in my northern native land.

From *Popular Astronomy*, by F. Arago (tr. by Smyth and Grant), 1858, Vol. II, p. 353.

Now, the annals of astronomy contain observations of many total eclipses of the moon, accompanied by an entire disappearance of that body. Hevelius relates

that no trace of our satellite was visible during the eclipse of the 25th of April, 1642. Maraldi relates that he observed a similar phenomenon on several occasions. And according to MM. Beer and Mädler, the moon also disappeared entirely both in London and at Dresden, during the eclipse of the 10th of June, 1816.

As the cone into which the moon penetrates when she ceases to be visible, must have for its axis the line passing through the centre of the sun and the centre of the earth, it appears impossible that the eclipsed moon should ever be seen above the horizon at the same time with the sun.

Cleomedes remarks that a statement to this effect which had been recorded by authors earlier than himself, was a mere imaginary story invented to perplex astronomers.

Yet it is certain that during the eclipse of the 16th of June, 1666, seen in Tuscany, the moon rose eclipsed, the sun being still above the western horizon, a circumstance which seemed to imply that the two bodies were not diametrically opposite to each other relatively to the centre of the earth. We may also quote the eclipse that was observed at Montmartre, the 26th of May, 1668, by the members of the Academy of Sciences, on the occasion of which the same peculiarity occurred.

Yet this phenomenon is inconsistent, only in appearance, with the theory of eclipses. Atmospheric refraction causes both the sun and moon to appear in positions which they do not really occupy. Refraction accelerates the apparent rising of the moon, and retards the apparent setting of the sun.

Although in the two instances that we have cited, the two bodies were both below the horizon, the rays of light emanating from the various parts of their discs reached the eye of the observer by pursuing a curvilinear route through the atmosphere.

By taking from the tables - - the value of atmospheric refraction at the horizon, we shall explain the phenomenon of the simultaneous apparition of the two bodies, in 1666 and 1668, even to the minutest numerical details.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Electric Waves — a Retrospect

It has been said that as a person grows old he becomes more reminiscent; and the writer hopes he may be pardoned for reprinting the short article below. It refers to a lecture delivered on February 8, 1896, and is just as it appeared in the Saturday edition of *The Globe* (Toronto) a week later.

For several years during the "nineties" a series of popular Saturday lectures was offered to the public each academic season by the University of Toronto. Two of the speakers stand out in the writer's memory — Dr. W. H. Drummond, of Montreal, the "Habitant-Poet"; and Ernest Seton Thompson, the author of "Wild Animals I have Known," who lived for years in Toronto and who later assumed "Seton" for his surname. They were both admirable and charming entertainers.

The writer was asked to give on the date above an address on "Electric Waves," a subject receiving at that time the attention of physicists all over the world. The apparatus used in the demonstrations had been newly constructed at the University and was somewhat similar to that devised by Oliver Lodge in England. With its assistance, on November 25, 1895, the physical characteristics of electric waves had been explained and illustrated experimentally to the Astronomical and Physical Society.

This was a fruitful period for discoveries in physical science. In the year 1895 Roentgen discovered the X-rays, and in 1896 H. Becquerel detected the radiation from uranium compounds and soon afterwards there followed Madame Curie's discovery of radium.

When we look about and see the multitudinous applications of electric waves at the present time —wireless telegraphy, ordinary radio and public address systems, television and walkie-talkie, radar including the reflections of its waves from the moon, and for other very important purposes,—it will be realized that the quiet picture of "Pure Science" presented in the last paragraph of the lecture has changed enormously in the last fifty years.

On Saturday afternoon of last week Mr. C. A. Chant, B.A., lecturer in physics at the University of Toronto, delivered a very able address on "Electric Waves." Regarding this he said: The subject of electric waves has sprung into great prominence during the last few years. Since 1888 this question has occupied physical investigators more than any other, and contributions to its study have been received from every part of the globe. Yet the suddenness of its development is only apparent; extensions in science are never made in a day.

> "Not a truth has to art or to science been given,
> But brows have ached for it, and souls toil'd and striven."

We see to-day the magnificent flower, but the seeds were carefully sown in the scientific soil more than half a century ago by Michael Faraday.

The beginning is to be seen in Faraday's endeavour to explain how a magnet or an electrified body affects another at a distance from it. He tried to trace the action from one body to the other, and showed that the space between the bodies was an important consideration. The induction of currents, which is the fundamental principle in modern electrical machinery, was discovered and explained in the same way. Faraday then tried to measure the time required for the magnetic or electric force to travel to the other body influenced; but here he was unsuccessful. No test was delicate enough.

The work was taken up by James Clerk Maxwell, who was born in Edinburgh, 1831, and died in 1879. Maxwell applied mathematics, of which he was a master, to Faraday's researches, and in 1856 and 1864 published important papers, and his complete two-volume work in 1873. That work is yet the standard, all others published since then being largely commentaries on it. In his 1864 paper Maxwell deduced that electric and magnetic forces are propagated with a certain velocity, and on measuring the constants on which it depends it was found to be almost identical with that of light, namely, 186,000 miles a second.

Though this conclusion was published thus early, few accepted it seriously as no one had observed and measured directly the electric waves which on this theory were propogated just as light in the ether, that attenuated medium filling all space. We can work with light waves easily, as the retina is so sensitive to them, but no one knew how to detect electcrc waves.

It was the discovery of a method of doing this which aroused the present absorbing interest in the subject. The great honour is due to Heinrich Hertz, a young German professor. In 1886 he happened to see a little spark where he had not expected it, and the method to be used was thus suggested to him. He lost no time in following up the clue, and in a series of brilliant papers developed the subject in an almost ideal manner. Hertz showed how to observe and measure these waves, and showed that they followed all the ordinary laws of optics — in fact identified light as an electric phenomenon. Hertz died in 1894, January 1, aged 37, but his recognition has been instant and complete, and his grave was one honoured by every nation.

The method of exciting these electric oscillations was then shown; three radiators, i.e., instruments for sending forth these waves, were exhibited in action.

The first consisted of two zinc plates, from each of which a rod ending in a knob came. These knobs were close together, and sparks from a large induction coil passed between them. The second was a five-inch sphere, with small knobs on each side; and the third was a two-inch cylinder, with knobs inside it. Two receivers, or detectors, were used. One was a simple brass circle, cut, and two knobs on the severed ends. Sparks could be made to pass between these when the first radiator was in action, even though several feet away. The other consisted simply of a small tube, nearly full of iron turnings. The electric waves have a very peculiar effect on this. As it ordinarily stands its resistance to the passage of an electric current is very great, but when the waves get amongst the turnings these seem to slightly cohere, and the resistance falls very decidedly. By putting a galvanometer and battery in circuit with it this change in resistance—and hence the presence of electric waves—can be detected. By simply tapping the tube the coherence is destroyed, and the tube is ready for action again.

Another very pretty experiment, exhibiting the behaviour of these waves, was shown. In it two Leyden jars were used, and by "tuning" them to unison a spark could be made to appear in one when a spark was excited in the other.

By enclosing the spherical radiator in a copper cylinder, open at one end, and the tube of turnings in another cylinder, the effect was shown at greater distances. Very decided action in the tube took place even when at the farther side of the room from the radiator — 30 or 35 feet away. The length of the electric waves with this radiator is about 18 inches, and they occur 600,000,000 to the second.

Experiments were then shown similar to those in optics. From the spherical radiator in the copper cylinder a horizontal beam was projected. The receiver was placed so that the galvanometer showed no effect, but on placing a brass sheet in the correct position the beam was reflected into the receiver, which responded decidedly. Then a large pitch prism was used. This was about 18 inches high, was made of roofing pitch, and weighed about 70 pounds. The radiator and receiver were brought near each other and turned so that the galvanometer was only slightly affected, but on introducing the prism the rays of electric force got through more easily, and at once the galvanometer responded. An experiment similar to that performed on polarized light with two plates of tourmaline, was performed with two grids of copper wires.

Reference was also made to the recent discovery of Roentgen and the apparatus as used was shown in operation — the induction coil, the Crookes tube, and the object before the plate-holder. Some of the shadow pictures obtained at the University during the week were also exhibited. These leave no doubt of the genuineness of the discovery, but, being early attempts, the pictures are not so definite and clear as later ones no doubt will be.

The lecturer concluded as follows:—"I hope I have shown you that there is radiant electricity as truly as there is radiant light; and, moreover that they follow similar laws. The present trend of physical theory is seen in the attempt to explain the forces of magnetism, electricity, gravitation, etc., asdue to the action of an omnipresent ether. Let me add one more word. Many of you, no doubt, would like to know of any practical application of the great discoveries to which

reference has been made. On this side of the ocean we are very prone to ask what is the money value of it, especially when electricity is concerned. The very mention of that word usually calls before the mind pictures of steam-engines and dynamos, rattling street-cars and brilliant street lamps, unsightly telephone and telegraph poles, or perhaps a covetous wish for some of the half-yearly dividends. But I do not know that a single dollar has been invested to exploit any application of this new principle. The three physicists whose names are prominent in its development — Faraday, Maxwell and Hertz — are three beautiful examples of men who have devoted extraordinary abilities to the cause of purely scientific investigation, which is indeed the highest interest of mankind, knowing well that 'science is, like virtue, its own exceeding great reward.' "

The writer would like to add that the young reporter who got the "story" for the newspaper was William Lyon Mackenzie King, who graduated B.A. from the University of Toronto in 1895, and who on June 10, 1946, began his twentieth year as Prime Minister of Canada —a record unequalled by any of his predecessors in that high office.

C.A.C.

MEETINGS OF THE SOCIETY

AT TORONTO

October 9, 1945—The Society met at 8.00 p.m. in the McLennan Laboratory, University of Toronto; Mr. H. W. Barker in the chair.

The Chairman reported that Council had met twice since the last lecture meeting and, in addition to arranging for the series of summer outdoor meetings and fall lecture programme, had adopted a Constitution and By-Laws for the Centre as required by the Revised Constitution of the General Society. Chief points of interest in the Centre's Constitution were: (1) the presiding officer is henceforth to be known as President instead of Chairman; (2) there will be two vice-presidents instead of one; (3) provision is made for establishing a Junior Membership whenever this is deemed advisable, and (4) the elective Councillors will be elected on a rotation basis, with one-third of them retiring each year. Council had also given consideration to formation of a telescope makers' section and those interested were asked to notify the Executive.

Several speakers reported on their experience with parties which went to Western Canada to observe the total solar eclipse on July 9.

Mr. S. C. Brown who was at Bredenbury, Sask., with a party headed by Dr. Donald Menzel of Harvard College Observatory, at the time serving as Lieutenant-Commander in the U.S. Navy, said this group was probably the best-equipped expedition which ever went out to observe any solar eclipse. The group worked long hours daily for a month making preparations to view the eclipse of 36 seconds duration. Twelve of the 14 cameras were built on the site; the largest, a 10½-foot coronal camera being designed to take only one "shot." Temperature at Bredenbury varied from 38° to 99° in the shade, and there were four days of continual rain. During the eclipse, although clouds prevented any view of it, every observer went through all the pre-arranged motions at the instruments "just in case a break in the overcast might permit some useful information to be obtained," Mr. Brown said.

Dr. J. F. Heard, then a Squadron Leader in the R.C.A.F., reported on the aerial eclipse expedition. "This was really Dr. Millman's show," he said. "A lot of the work had to do with study of the possible effects of the eclipse on propagation of radio waves, a matter in which the air force was interested." Three planes from the R.C.A.F. Photographic Wing at Ottawa were equipped with specially adapted cameras for spectroscopic and direct photographs, and were accompanied by eight aircraft to make visual observations from the R.C.A.F. station at Rivers, Man. The cameras were fixed and it was the problem of pilots not to aim their cameras, but to aim the plane while the sun was kept in a sort of gunsight. Of the three photographic planes, the Spitfire photo-

graphed the eclipse at 37,000 feet, the Mitchell at 25,000 and the Anson at 17,000. Some of these observations were made almost directly above Bredenbury where clouds obscured the view of ground observers.

Mr. J. R. Collins said he went privately to Roblin, Man., where a group of Rhode Island amateur astronomers was also located. Clouds prevented view of the eclipse at this point. Mr. Collins recounted some of his experiences on previous eclipse expeditions.

Mr. G. A. Purdy said he had been invited to go to Bredenbury " as a sort of assistant. I thought that might mean handing up an odd screwdriver to one of the scientists, but first thing Dr. Menzel asked when I arrived was: 'How would you like to build a coronal camera?' I must confess I didn't even know what that was, but we did a lot of improvising and finally had it built. I soon found out, however, that an eclipse expedition isn't any holiday." Mr. Purdy exhibited an album of pictures of the campsite and the observers, many of them illustrating the human interest side of the expedition as seen by a layman.

Dr. Heard then presented the first in a series of five short papers on "Spectroscopy," in which he dealt with the nature of light under the following heads: Wave motion, wave nature of light, speed of light, wave-length, the Angstrom unit, and the spectrum.

October 23, 1945—The Society met at 8.00 p.m. n the McLennan Laboratory, Mr. Barker in the chair.

Five persons were elected to membership in the Society, viz:

Mr. William Douglas, 60 Winnifred Avenue, Toronto.
Miss Verona I. Guthrie, 308, 18 Wellesley Street, Toronto.
Mr. Eric P. Henderson, 159 Parkmount Road, Toronto.
Mrs. Adele Milnes, 17 Humewood Drive, Toronto.
Rev. Ed. G. Robb, 9 Avalon Blvd., Toronto.

Rev. C. H. Shortt addressed the Society on "Astronomy and the Bible." The Scriptures were not intended to reveal things man could find out for himself, nor to be a guide to modern sciences, but to reveal the nature of God, he said. The general opinion is that the Old Testament is the polytheistic Babylonian preface, altered sufficiently so as not to conflict with the Hebrew people's idea of God.

There was no astronomy—none whatever—in Bible times except at the very last. There was astrology—literally, learning about the stars—and most peoples believed the stars, every one of them, was the home of some deity, some good, some evil. That is the reason the stars are never mentioned with much favor in the Old Testament. The Hebrews saw in star study a danger of corruption to their faith in one God in that idea that the stars were homes of influence of whatever pagan god lived in each one of them.

Astronomy—literally, star law—was practically unknown in Biblical times. There was a good knowledge of astronomy in China, but it is doubtful if much of this reached the Hebrews. The ancient astrologers did observe and measure the stars a great deal, but it was not astronomy although we do owe them a great deal. Egypt was full of star worship and each temple was oriented

with reference to some particular star. Although astronomy was considerably advanced by the Greeks, it wasn't until Copernicus and his disciples in the 16th century that we find the beginnings of real astronomy. The biggest leap in all astronomical progress, I think, was in 1860 when the spectrum was discovered. Thus, we see, all through Bible days there was no conflict between the Bible and astronomy because there was no astronomy; today there is no conflict because those who believe the Bible and those who are lovers of astronomy hold each other in sufficient respect to be assistants to each other.

On behalf of the audience, Rev. Dr. D. W. Best moved an informal expression of appreciation to Mr. Shortt.

Dr. J. F. Heard presented the second paper in the series on "Spectroscopy," briefly describing how spectra are produced by prisms and gratings, the relative advantages of each method, the difference between spectroscopes and spectrographs, and the use of the slitless spectrograph.

November 6, 1945—The Society met at 8:00 p.m. in the McLennan Laboratory, Mr. Barker presiding.

One candidate was elected to membership in the Society, viz:

Mr. Hillel H. Diamond, 637 Euclid Avenue, Toronto.

Dr. D. C. Jones, physicist of Research Enterprises Limited, spoke on "Recent Trends and Developments in the Optical Industry." Until 1939, when war brought need for all-out production, optical manufacturing in the U.S. and in Britain was largely a matter of trade secrets guarded jealously by individual firms. The industry lacked the standardizing influences and the tendency to share developments that come from common machine-tool practice. Most of the new things that came about during the war, however, were the result of shared research and published data. In the past, the artisan had pioneered by the trial-and-error method and sometimes scientific research followed; during wartime the procedure was reversed and common shop practices brought the industry closer to the quantity production which eventually will mean lower costs.

Some of the new developments described were: (1) Vacuum-coating techniques by which films are applied to glass to reduce (or in some cases increase) the reflectance and loss of light; a further application of this is the aluminizing of mirrors in astronomical telescopes. (2) Substitutes for Canada Balsam were developed for use in cementing lenses, these being polymerized plastics capable of withstanding prolonged tests in a temperature range from minus 60° up to 160°. (3) Cerium oxide and other rare earths were found more efficient than jewellers' rouge in polishing optical glass.

Dr. J. F. Heard then presented his third paper on "Spectroscopy," in which he dealt with Laboratory Spectra. In this he discussed the difference between emission and absorption spectra, and continuous, line and band spectra.

Moved by W. R. Sherrick, seconded by C. A. Crook, that a Nominating Committee, comprising the three immediate Past Chairmen—Miss Northcott, Dr. Best and Mr. Brown—be named to report at the next meeting on Officers and Council for 1946.

November 20, 1945.—The Society met at 8.00 p.m. in the McLennan Laboratory, Mr. Barker presiding.

Two persons were elected to membership in the Society, viz:

Mr. E. J. Creighton, c/o Military Post-Office, Barriefield, Ont.

Mr. R. R. Miller, B.A., 445 Mortimer Avenue, Toronto.

Prof. Elizabeth Allin, department of physics, University of Toronto, addressed the Society on "Atomic Energy." A synopsis follows:

Until very recently, at least, atomic energy has perhaps found greater application in the astrophysical field than in any other. The fact that energy does have gravitational mass, the same as matter, was suggested by Einstein in 1905 and later was prover by observing the path of starlight being bent as it passed the sun during a total eclipse. It was just another step to the theory that energy could be transformed into matter, or matter into energy. It has been calculated that the potential energy which could be derived from the transmutation of one kilogram of matter would be equal to the output for two months of all the electric power plants in the U.S. in 1939. This opens up the idea that perhaps here we find the secret of how the sun and stars continue radiating without consuming themselves.

In 1919, Lord Rutherford at Cambridge showed it was possible to break up the nucleus of an atom by bombarding it with particles of sufficiently high velocity, and by this process it was found possible to transmute one kind of nucleus to another. This suggested a number of ways in which atomic energy could be built up in the stars. Until the recent development of the atomic bomb, however, it had been impossible to produce any large-scale liberation of energy on the earth.

Prof. Allin explained in detail the principle of fission in atoms as the nucleus is bombarded by an external neutron; for example, a neutron particle striking the nucleus of a U-238 atom might cause it to release one or more of its own neutrons, forming an isotope of less atomic weight. In this manner, U-235 can be produced from U-238, the normal form of the uranium atom. On the other hand, a neutron striking a U-238 atom might adhere to it, forming U-239, a highly unstable form of uranium which breaks up to form neptunium, and in a further breaking up this forms plutonium, the new element used in the atomic bomb. Plutonium is very slowly radioactive, it exhibits all the fission qualities of U-235, and is just as easy to split. The atomic bomb explosion was brought about by bringing together in one place a critical amount of plutonium—then the explosion was spontaneous. The quantity needed is the main secret about the bomb, and also just how the device is constructed to prevent premature explosion. The rest of the process is just a matter of ordinary nuclear physics. "We don't know, but we suspect that U-235 would explode of itself if enough were produced and kept together," she added.

The speaker went on to explain how these chain reactions are caused as neutrons given off by one atom bombard other nuclei and the process is repeated over and over. The problem in producing plutonium for the atomic bomb was to keep a proper balance—to keep the reaction going at the right speed without getting out of hand and causing an atomic explosion. It was also necessary

to slow down the neutrons to the speed most likely to effect the desired fissions. A moderator was used for this purpose—graphite in the U.S. development work. Germany had planned to use "heavy water" for such a moderator, and this is also under consideration for Canada's projected plutonium plant at Chalk River, Ont. It was explained that if the uranium and the moderator are arranged properly, a stray cosmic ray neutron could start the chain reaction in the "pile," and then if it were kept going at the proper rate, a considerable quantity of plutonium could be produced. A terrific amount of heat is produced in these piles and it may be possible to devise some method of utilizing it.

So far such a tremendous output of energy has not been harnessed. We still do not know how to use atomic energy in this form except to destroy what we have created in other ways. We can turn matter into energy, but we haven't yet learned how to reverse the process.

Dr. J. F. Heard gave the fourth paper on "Spectroscopy," dealing with Spectra of Heavenly Bodies. He reviewed the general character of stellar spectra, spectral sequence, and the Doppler effect and radial velocity. Most of our knowledge of the physical nature of the sun had been obtained by detailed spectroscopic investigation. Nature of the atmospheres of the planets was revealed by the absorption bands which appear in the sunlight reflected from them. The nature of comets, meteors and nebulae was also revealed by study of their spectra, and meteor spectra gave evidence of conditions in the earth's upper atmosphere as well.

Dr. D. W. Best reported for the Nominating Committee appointed by the previous meeting. There being no further nominations for Officers or Council it was moved that the report be adopted and presented to the Annual Meeting of the Centre on December 4.

December 4, 1945.—The Society met at 8.00 p.m. in the McLennan Laboratory, Mr. Barker presiding.

Six persons from Toronto were elected to membership in the Society, viz:

Mr. Thomas H. Brown, 96 Fulton Ave.
Mr. Bruce Flann, 126 Edgewood Ave.
Mr. E. E. Wells, 85 Richmond St. W.
Mr. David H. Campbell, 2141 Bloor St. W. (Apt. 6).
Mr. Ephraim Merkur, 16 Claxton Blvd.
Mr. Henry Shanfield, 479 Dundas St. W.

Dr. Helen S. Hogg drew attention of those present to the coming total eclipse of the moon on December 19.

Mr. R. H. Craddock, M.A., of the staff of Vaughan Road Collegiate Institute, then addressed the meeting on "Weather Forecasting." This paper will be printed in the JOURNAL.

Dr. J. F. Heard, in the fifth paper in the series on "Spectroscopy," reviewed the information provided in the four earlier papers and demonstrated several of the fundamentals by use of laboratory apparatus.

The meeting was then adjourned, to be followed immediately by the Annual Business Meeting of the Centre.

FREDERIC L. TROYER, *Recorder.*

AT MONTREAL

October 25, 1945—The Montreal Centre held its twenty-seventh annual meeting. Reports were submitted by the Secretary, the Treasurer, the Director of Observations and the Librarian, and the election of officers for the coming year took place. Mr. D. P. Gillmor, K.C., the retiring President of the Centre, then addressed the meeting. This address is published in full in the February issue of the JOURNAL.

November 24th, 1945—Dr. W. Bruce Ross, Assistant Professor of Mathematics, McGill University, addressed the Montreal Centre on "Tools of the Astronomer."

An astronomer is a unique kind of scientist, Dr. Ross said, for he has so little to work on compared with scientists in other fields. Actually he relies solely on waves of light, but with the help of various instruments he has learned to measure these waves and thereby to determine much about celestial objects.

Early telescope makers aimed at great magnification, making instruments of longer and longer focal length. The distortion of the image increased proportionately, however, and it was soon found that a sharp image was of more importance than magnification, and the long narrow tubes were replaced by telescopes of larger aperture. The first telescopes were of the refractor type, the reflectors coming into use in more recent times. Dr. Ross explained the principle of the two types, pointing out the advantages and disadvantages of each. The refractor has several undesirable effects, diffraction of light being, perhaps, its most serious drawback. Even the use of achromatic lenses does not solve this problem satisfactorily, for these correct for two colors only. Thus, in refractors used for visual work, the reds and yellows are corrected, while in those intended for photographic purposes, the blues and violets are corrected.

Dr. Ross went on to explain how the light, received with the aid of the telescope, is broken up by the use of a prism or grating and the resulting spectra analysed and interpreted. The grating is an improvement over the prism for one can get the ultra violet rays since there is no lens for the light to pass through.

Dr. Ross also touched briefly on the construction and uses of the spectroheliograph, the thermocouple and the Schmidt camera. With the full equipment of the physics laboratory at his disposal, he demonstrated each point in a very effective way and then reminded his spellbound audience that modern instruments, wonderful as they may seem, are useless without the brain of the astronomer to direct them.

December *14, 1945*—The meeting of the Montreal Centre on Friday, December 14th, 1945, was held in the Montreal High School where members had the opportunity of inspecting the planetarium. The gift of the school's alumni, the planetarium was installed in May 1945 at an approximate cost of five thousand dollars. As Mr. D. C. West, when demonstrating it, pointed out, it is not to be compared to a million dollar structure such as the Hayden Plan-

etarium, but is simply a school teaching device— the first of its kind, it is believed, to be put into use in Canadian schools.

The planetarium occupies one corner of the school auditorium. It has a diameter of twenty-one feet and can accommodate about forty persons. The equipment consists of an orrery, the dome and projector. The orrery has already proven very useful in connection with the study of physical geography, Mr. West said. He showed how simply the movements of the earth and planets, the changes of the seasons and the phases of the moon can be explained to the children with its help.

Around the rim of the dome are the signs of the zodiac, while the dome itself is studded with stars to the fifth magnitude, againsst a deep blue background, representing the evening sky in July in northern latitudes. When the lights are turned out, these stars, of course, become invisible, and by means of the projector the sky for any latitude and season can be demonstrated. The children are expected to become familiar with the main constellations and to learn something of the diurnal motion of the stars and of the movements of the moon and planets in relation to the stars. Mr. West made a number of effective demonstrations. A gradual dimming of the lights gave a very realistic effect of sunset as the sky darkened and the stars became visible, and the demonstration of sunrise was equally impressive.

As the audience on this occasion was too large to be accommodated in the planetarium at one time, it was divided into two groups, one group viewing a film on celestial navigation while the other visited the planetarium, and the two groups then changing places.

At the close of the meeting Mr. F. DeKinder expressed the thanks of the members to Mr. L. Unsworth, Rector of the High School, for the use of the school facilities, to Mr. West for his lecture in the planetarium, and to Mr. H. D. McKnight for operating the film projector, all three having combined to provide a most interesting and entertaining evening.

ISABEL K. WILLIAMSON, *Recording Secretary.*

AT WINDSOR

February 12, 1946.—The Windsor Centre met at 8 p.m. in the Art Gallery of Willistead Library, Mr. C. B. Hallam presiding.

The president called to our attention the new library service. With the co-operation of the Willistead library staff, public library books and magazines on astronomical subjects are on display at every meeting. These books and the ones belonging to the Centre may be borrowed until the following meeting by members and visitors. Councillor E. J. Edwards has accepted the office of librarian and will look after the circulation.

The following were proposed and accepted for membership in the Centre: Mrs. D. C. Bawtenheimer, Messrs. J. W. Dowden, W.C. Oberem, Dr. R. O. Fuerbringer, the last two of Detroit.

The president led a discussion of many points in the OBSERVER'S HANDBOOK, giving helpful advice on the use of the tables and charts. He reviewed

recent current events, noting the increased sunspot activity and the radar contact with the moon. Interesting information about the recent nova, T. Coronae Borealis, from Norton's Star Atlas was discussed.

The chief speaker of the evening, Mr. Cameron H. Montrose, B.Sc., spoke on the subject "Glaciation and the Ontario Landscape." He recalled that, as a boy, when on fishing trips he had observed scratches on an outcropping of limestone near Jarvis, Ontario Later, on dscovering the cause, he became interested in the effects of glaciation on Ontario.

Aided by a series of fine pictures, Mr. Montrose explained how a glacier is formed, and named its parts. He used a particularly interesting set of maps to demonstrate how the great ice age caused the Great Lakes and brought other changes to Southern Ontario. Of special interest to Detroiters and Winsorites were the maps showing the interlobate moraine which crosses Michigan, Detroit, Windsor and Essex County. Mr. Montrose stressed that we are in a recessive period as far as glaciers are concerned. Warmer weather is indicated for this section of the world.

The speaker reviewed a number of the possible causes of the Ice Ages. He said that an average of ten degrees F. colder would bring the return of glacier conditions. We should rule out the Precession of the Equinoxes as a contributory cause, because the Ice Ages do not appear with regularity. Mr. Montrose humorously remarked that, whatever the cause, we need not fear the return of the Ice Age for a few thousands of years.

Councillor E. M. Krebser expressed the thanks of the Society to Mr. Montrose for his lecture. The president invited all present to attend the next meeting on March 12. The meeting was then adjourned.

R. G. Warwick, *Secretary.*

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1890-1946

The Society was incorporated in 1890 under the name of The Astronomical and Physical Society of Toronto, and assumed its present name in 1903.

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal and Quebec, P.Q.; Ottawa, Toronto, Hamilton, London and Windsor, Ontario; Winnipeg, Man.; Edmonton, Alta.; Vancouver and Victoria, B.C. As well as over 1,000 members of these Canadian Centres, there are over 400 members not attached to any Centre, mostly resident in other nations, while some 50 additional institutions or persons subscribe to our publications.

The Society publishes a monthly "Journal" containing about 500 pages and a yearly "Observer's Handbook" of 80 pages. Single copies of the "Journal" or "Handbook" are 25 cents, postpaid. In quantities of 10 or more copies, the price is 20 cents a copy.

Membership is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00. Publications are sent free to all members or may be subscribed for separately. Applications for membership or publications may be made to the General Secretary, 3 Willcocks St., Toronto.

The Society has for Sale:

Reprinted from the "Journal" of the Royal Astronomical Society, 1936-1944.

The Physical State of the Upper Atmosphere, (revised 1941) by B. Haurwitz, 96 pages; Price 75 cents postpaid.

General Instruction for Meteor Observing, (revised 1940) by Peter M. Millman, 24 pages; Price 15 cents postpaid.

A Yoke Mounting for the Six-inch Telescope, by H. Boyd Brydon, 8 pages; Price 10 cents postpaid.

Setting Up and Adjusting the Equatorial Reflecting Telescope, by H. Boyd Brydon, 25 pages; Price 25 cents postpaid.

Occultations: their Prediction, Observation and Reduction, by H. Boyd Brydon, 76 pages, 1944; Price 60 cents.

In quantities of ten or more copies, a discount of 20 per cent will be allowed. Send Money Order to 3 Willcocks St., Toronto.

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